

**Space Project Mission Operations Control
Architecture (SuperMOCA)**

SuperMOCA SYSTEM CONCEPT

Ancillary Document 1

**Ground Terminal Reference
Model**

May 1997



ORIENTATION

The goal of the Space Project Mission Operations Control Architecture ("SuperMOCA") is to create a set of implementation-independent open specifications for the standardized monitor and control of space mission systems. Monitoring is the observation of the performance of the activities of these systems. Controlling is the direction of the activities performed by these systems. Overall, monitor and control is the function that orchestrates the activities of the components of each of the systems so as to make the mission work. Space mission systems include:

spacecraft and launch vehicles that are in flight, and;
their supporting ground infrastructure, including launch pad facilities and ground terminals used for tracking and data acquisition.

The SuperMOCA system concept documents consist of the following:

SuperMOCA System Concept, Volume 1: Rationale and Overview
SuperMOCA System Concept, Volume 2: Architecture
SuperMOCA System Concept, Volume 3: Operations Concepts
SuperMOCA System Concept, Annex 1: Control Interface Specification
SuperMOCA System Concept, Annex 2: Space Messaging Service (SMS) Service Specification
SuperMOCA System Concept, Annex 3: Communications Architecture
SuperMOCA System Concept, Ancillary Document 1: Ground Terminal Reference Model
SuperMOCA System Concept, Ancillary Document 2: Operations Center to Ground Terminal Scenarios
SuperMOCA System Concept, Ancillary Document 3: Operations Center to Ground Terminal – Comparison of Open Protocols

These documents are maintained by the custodian named below. Comments and questions to the custodian are welcomed.

Michael K. Jones
MS 301-235
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
Voice: 818-354-3918
FAX: 818-354-9068
E-mail: michael.k.jones@jpl.nasa.gov

Super MOCA Ground Terminal Reference Model

Contents

SECTION	PAGE
1. INTRODUCTION.....	1-1
1.1. SCOPE	1-1
1.2. CONTEXT.....	1-1
2. GROUND TERMINAL REFERENCE MODEL ANALYSIS APPROACH.....	2-1
3. THE GROUND TERMINAL REFERENCE MODEL.....	3-1
3.1. IDENTIFICATION OF SYSTEMS	3-1
3.1.1. Ground Terminal Systems Categories.....	3-1
3.1.2. Ground Terminal Operations Support Systems.....	3-1
3.1.3. Planning and Scheduling System.....	3-3
3.1.4. Systems Level Model.....	3-3
3.2. IDENTIFICATION OF OBJECTS WITHIN SYSTEMS.....	3-4
3.2.1. Space Link Systems.....	3-4
3.2.2. Space Data Systems.....	3-7
3.2.3. Tracking Systems.....	3-9
3.2.4. Radio Science System.....	3-15
3.2.5. Correlative System.....	3-16
3.2.6. Planning and Scheduling System.....	3-16
3.2.7. Ground Communications System.....	3-17
3.2.8. Data Objects.....	3-17
3.3. CONTROL AND DATA FLOW MODELS	3-18
3.3.1. System Level Control and Data Flow Model.....	3-18
3.3.2. Object Level Control and Data Flow Model. Error! Bookmark not defined.	
4. ISSUES LIST	4-1
4.1. DECISION SUPPORT LOGIC.....	4-1
4.2. OPERATIONS MANAGEMENT.....	4-1
4.3. COMMUNICATIONS STACKS.....	4-1
4.4. PROTOCOL INTERFACES	4-3
4.5. SCPS PROTOCOLS	4-3

Figures

FIGURE	PAGE
FIGURE 1-1 - TASK CONTEXT.....	1-2
FIGURE 2-1 - GROUND TERMINAL AS SERVER	2-1
FIGURE 2-2 - CONTROL ORIENTED OBJECT	2-2
FIGURE 3-1 - GROUND TERMINAL SYSTEMS CATEGORIES	3-1
FIGURE 3-2 - GROUND TERMINAL OPERATIONS SUPPORT SYSTEMS.....	3-2
FIGURE 3-3 - EXAMPLE CONTROL SYSTEM FUNCTIONS.....	3-2
FIGURE 3-4 - PLANNING AND GROUND TERMINAL SCHEDULING SYSTEM	3-3
FIGURE 3-5 - SYSTEMS CATEGORIES REFERENCE MODEL.....	3-3
FIGURE 3-6 - SYSTEMS WITHIN THE SPACE LINK SYSTEMS CATEGORY	3-4
FIGURE 3-7 - ANTENNA SYSTEM OBJECTS	3-4
FIGURE 3-8 - EXAMPLE ANTENNA SYSTEM IMPLEMENTATION	3-5

Super MOCA Ground Terminal Reference Model

FIGURE 3-9 - TRANSMITTING SYSTEM OBJECTS.....	3-5
FIGURE 3-10 - EXAMPLE TRANSMITTING SYSTEM IMPLEMENTATION	3-6
FIGURE 3-11 - RECEIVING SYSTEM OBJECTS	3-6
FIGURE 3-12 - EXAMPLE RECEIVING SYSTEM IMPLEMENTATION.....	3-6
FIGURE 3-13 - SYSTEMS WITHIN THE SPACE DATA SYSTEMS CATEGORY.....	3-7
FIGURE 3-14 - UPLINK SYSTEM OBJECTS	3-7
FIGURE 3-15 - EXAMPLE UPLINK SYSTEM IMPLEMENTATION	3-8
FIGURE 3-16 - DOWNLINK SYSTEM OBJECTS	3-8
FIGURE 3-17 - EXAMPLE DOWNLINK SYSTEM IMPLEMENTATION	3-9
FIGURE 3-18 - SYSTEMS WITHIN THE TRACKING SYSTEMS CATEGORY	3-9
FIGURE 3-19 - ANTENNA ANGLES MEASUREMENT SYSTEM OBJECTS	3-10
FIGURE 3-20 - EXAMPLE ANTENNA ANGLES MEASUREMENT SYSTEM IMPLEMENTATION	3-10
FIGURE 3-21 - TONE RANGING SYSTEM OBJECTS	3-11
FIGURE 3-22 - EXAMPLE TONE RANGING SYSTEM IMPLEMENTATION	3-11
FIGURE 3-23 - DOPPLER SYSTEM OBJECTS	3-12
FIGURE 3-24 - EXAMPLE DOPPLER SYSTEM IMPLEMENTATION	3-12
FIGURE 3-25 - RADAR SYSTEM OBJECTS	3-13
FIGURE 3-26 - EXAMPLE RADAR SYSTEM IMPLEMENTATION.....	3-13
FIGURE 3-27 - INTERFEROMETER SYSTEM OBJECTS	3-14
FIGURE 3-28 - EXAMPLE INTERFEROMETER SYSTEM IMPLEMENTATION.....	3-14
FIGURE 3-29 - RADIO SCIENCE SYSTEM OBJECTS.....	3-15
FIGURE 3-30 - EXAMPLE RADIO SCIENCE SYSTEM IMPLEMENTATION	3-15
FIGURE 3-31 - CORRELATIVE SYSTEMS OBJECTS	3-16
FIGURE 3-32 - PLANNING AND SCHEDULING SYSTEM OBJECTS	3-16
FIGURE 3-33 - GROUND TERMINAL COMMUNICATIONS MODEL	3-17
FIGURE 3-34 - DATA OBJECTS	3-17
FIGURE 3-35 - EXAMPLE SYSTEM LEVEL GROUND TERMINAL ARCHITECTURE.....	3-18
FIGURE 3-36 - EXAMPLE OBJECT LEVEL GROUND TERMINAL ARCHITECTURE	3-19
FIGURE 4-1 - SINGLE NETWORK EXAMPLE	4-2
FIGURE 4-2 - DUAL NETWORK EXAMPLE	4-3

1. INTRODUCTION

1.1. SCOPE

This document presents the development of a Ground Terminal Reference Model for use in the other parts of the Task. As stated in the Task Statement of Work, "An architecture of Ground Terminal Operations will be developed which will be used as a reference in the other subtasks. The architecture will reflect the preliminary work already accomplished within the SuperMOCA context, and will concentrate on the two primary control aspects of Ground Terminal operation. These are first the scheduling, controlling, and monitoring of the Ground Terminal resources, and second, the data reception, data transmission, and data handling which results from the use of those resources."

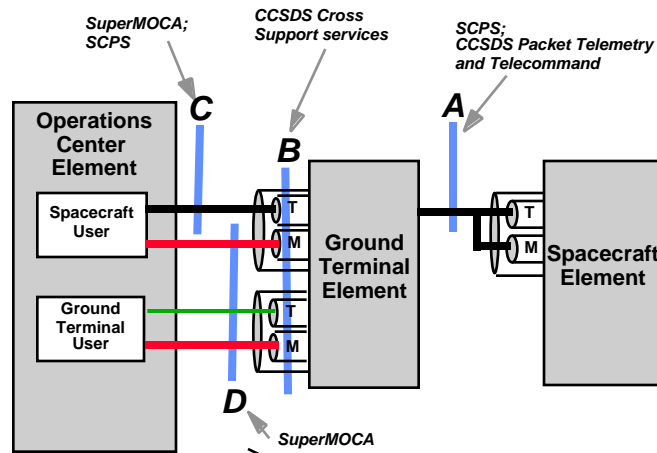
As the "Architecture" work progressed it became clear that what was needed and was being developed was a Reference Model, not an architecture. Architectures describe specific implementations of systems and groups of systems. The objective was to generalize *from* specific implementations to a first level of abstraction in order to examine the common characteristics of the several implementations. Therefore, this work is entitled "Ground Terminal Reference Model", instead of "Ground Terminal Architecture".

The purpose of the Reference Model is to help in the process of identifying common aspects of the systems and component systems constituting Ground Terminals, particularly common control points. This is to assist in the process of developing methods to control heterogeneous implementations in a common way. The Reference Model is *not* a recommendation for a standardized Ground Terminal implementation.

1.2. CONTEXT

A great deal of relevant work has already been accomplished within the Space Mission Operations Control Architecture (SuperMOCA) context and within the Consultative Committee for Space Data Systems (CCSDS). **Figure 1-1** shows a high level view of some of this work. This Task focuses on the Management channel for the Spacecraft User, and both the Management and Transport channels for the Ground Terminal User. This document presents the analysis for and a resulting "Users View" Reference Model of the "Ground Terminal Element".

Super MOCA Ground Terminal Reference Model



The Task will Focus on These Interfaces

Figure 1-1 - Task Context

2. GROUND TERMINAL REFERENCE MODEL ANALYSIS APPROACH

A Ground Terminal provides several functions to its user, including provision to the user of bi-directional communications links with the spacecraft (Space Link function), formatting of data for uplinking and synchronization to and demultiplexing of data received from the spacecraft (Space Data function), making requested measurements relating to the spacecraft's position (Tracking function), making requested measurements relating to the spacecraft's signal (Radio Science function), and making requested measurements relating to correlative conditions such as event times and weather (Correlative functions) (see **Figure 2-1**). In order to execute these functions, other functions are required, particularly ground communications with the user and support for Planning and Scheduling of Ground Terminal use. Each of the above functional groupings is a "Category". Within a Category (e.g. Tracking), several independent functional groups may occur (e.g. Tone Ranging, Radar). Each of these is identified and dealt with in the Reference Model. These independent functional groupings are referred to as "systems". Within the systems may be other systems, such as "receiving" within the "spacelink" system. Categories and systems are functional groupings, and systems map to superclasses of objects.

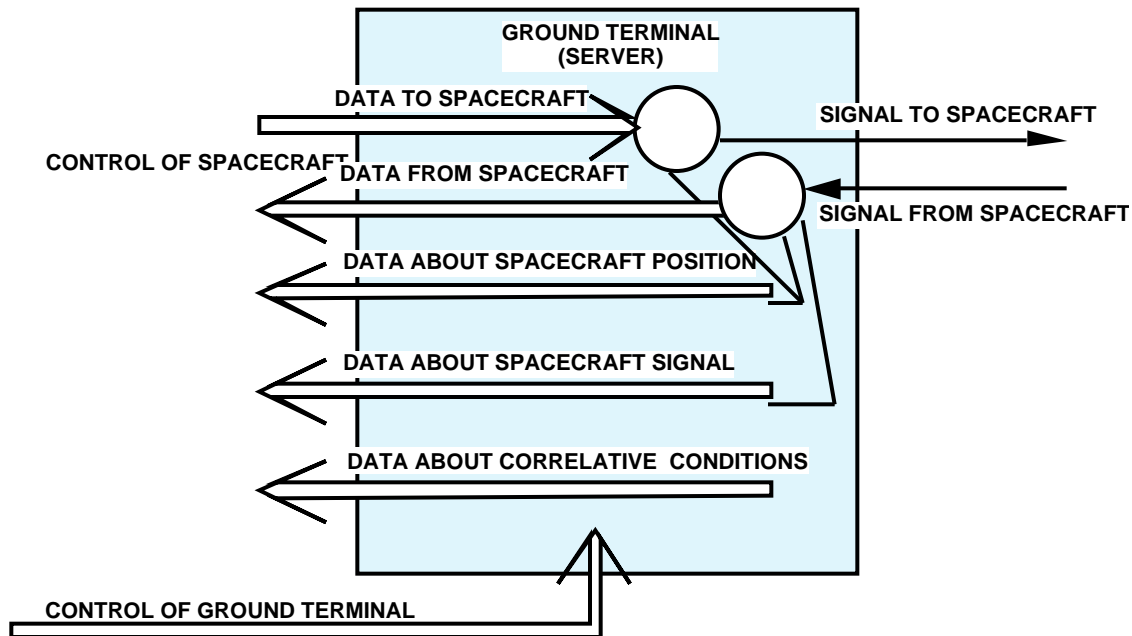


Figure 2-1 - Ground Terminal as Server

The central focus of the Reference Model is on controlling the Ground Terminal through controlling the (relevant) equipment in it. Because of this, the model concentrates on the actual equipment items of real ground terminals. A bottom-up process was generally used. Object Oriented Analysis techniques were used where productive, but the final Ground Terminal Reference Model is more a functional model than a software one, although it resembles a Shlaer-Mellor system model. The primary motivation for use of Object Oriented techniques in the Reference Model was to take advantage of the powerful concept of "inheritance". The objects identified in the model at the system and subsystem

Super MOCA Ground Terminal Reference Model

levels are superclasses. These are broken down into Objects. Further work in SuperMOCA may lead to the breakdown of these to specific controllable end-item hardware, and the definition of Virtual Mission Devices for them. The "inheritance" from the superclasses should be very useful in that process.

The Client-Server paradigm is used. The analysis concentrates on the Ground Terminal (Server) rather than the Operations Center (Client). This is the normal approach for Client/Server, i.e. the architecture/implementation of the Client is not specified.

The Reference Model is control oriented. The facet of interest of an item, e.g. a receiver, to the control view is not the primary real-world function of that item. It is the set-up, monitoring, and control of the receiver that is of primary interest. However, the fact that the receiver converts an r.f. input to a baseband signal is noted and is the facet of interest in the Client to spacecraft view, that is, the "Mainstream" aspect described in the Statement of Work.

An object may be a physical thing, a process, or data. In order to appear in the Reference Model, an object which is a "physical thing" (e.g. a receiver) must be visible to the Client, and to be visible to the client, a "physical thing" object must be controllable by the Client, or report to the Client, or both. A "physical thing" which is not visible to the Client, no matter how complex or expensive or important it is, is not an object within the present context. (It might, however, show up as an "attribute" of another object which is visible to the Client.) This concept is illustrated in **Figure 2-2**.

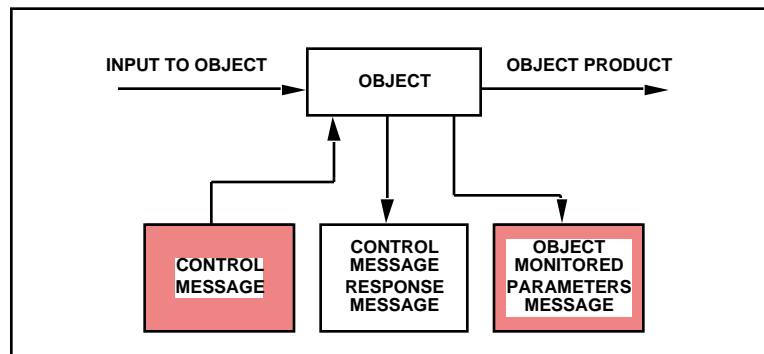


Figure 2-2 - Control Oriented Object

The first step in the process was the definition, within the specified domain, of the categories of functions provided and the systems contained in each category. The systems were then further broken down into component systems. At the level at which objects could be identified within a system the process ended, and with the identification of the objects the object model resulted. The purpose of the object model is to identify all parts of the domain which are visible from the perspective of interest, in this case the Operations Center (Client). The Ground Terminal object model is less than a complete Abstract Model - which would require identifying and describing every possible Ground Terminal object - but it is more than a straight derivation from a single example.

It should be noted that the analysis does *not* result in a formal OO description, and it does *not* define Objects (i.e. list the Attributes, etc.) but only identifies them.

Super MOCA Ground Terminal Reference Model

The objective was to create a model useful for analyzing the control aspects of a Ground Terminal, not to re-design or re-engineer it.

3. THE GROUND TERMINAL REFERENCE MODEL

3.1. IDENTIFICATION OF SYSTEMS

The domain of the Ground Terminal Reference Model is the Logical Ground Terminal. It is termed "Logical" because the model contains items which may in fact not be located in the physical Ground Terminal. An example would be that the Ground Terminal Capabilities data might be held in a database located at a ground network control center, rather than at the individual Ground Terminal(s).

The categories of systems within the domain are described below. They are grouped for convenience into those which execute functions for the client, those which allow control of the Ground Terminal to use those functions (including ground communications), and those which support planning and scheduling of the Ground Terminal.

3.1.1. GROUND TERMINAL SYSTEMS CATEGORIES

The first grouping of systems within the Ground Terminal is that of the Systems Categories which directly provide functions to the client. These are the Space Link Systems, Space Data Systems, Tracking Systems, Radio Science Systems, and Correlative Data Systems, as shown in **Figure 3-1**.

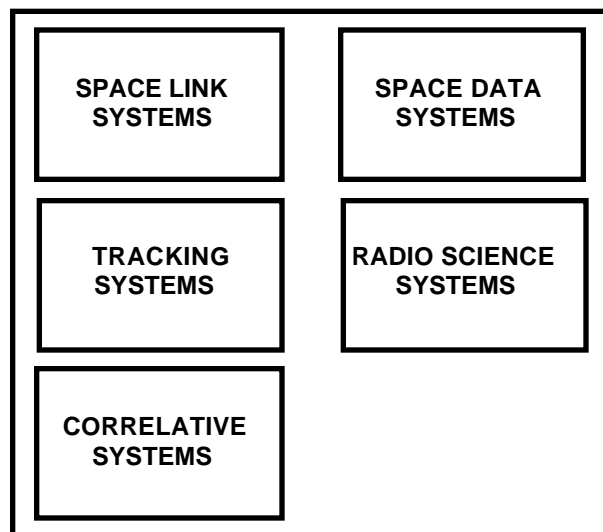


Figure 3-1 - Ground Terminal Systems Categories

3.1.2. GROUND TERMINAL OPERATIONS SUPPORT SYSTEMS

Each of the above Systems Categories has an associated control system (human or otherwise), as does the Ground Communication system. These are called Ground Terminal Operations Support Systems, and are shown in **Figure 3-2**.

Super MOCA Ground Terminal Reference Model

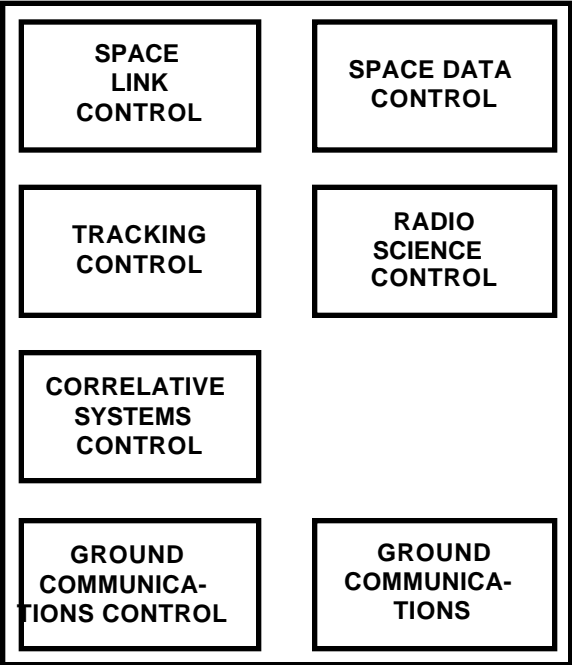


Figure 3-2 - Ground Terminal Operations Support Systems

A non-human control system has (at least) the functions shown in **Figure 3-3**, that is it provides control input, receives acknowledgment of the input, and monitors reports from the controlled item. In implementation, the control function may interface at the system level for "smart" systems, at the component systems level for "smart" (sub)systems, at the VMD level for standardized control interfaces, or directly at the device level. In this model, control is shown at the system level. In following models an increasing level of detail of control is shown.

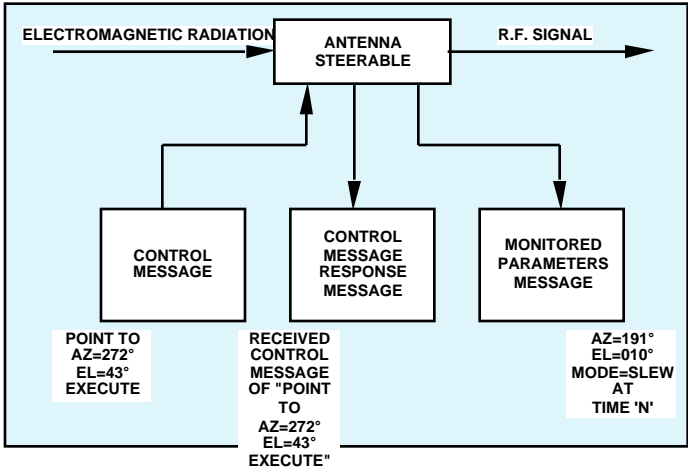


Figure 3-3 - Example Control System Functions

Super MOCA Ground Terminal Reference Model

3.1.3. PLANNING AND SCHEDULING SYSTEM

Two functions are provided in this area (**Figure 3-4**). First is the provision of information to potential clients for planning purposes, and second is the Ground Terminal scheduling process.

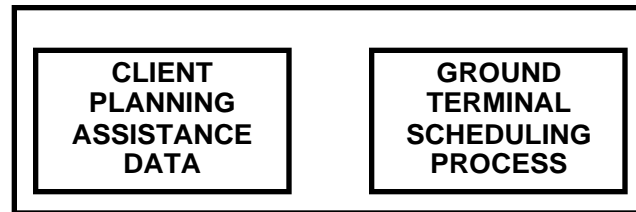


Figure 3-4 - Planning and Ground Terminal Scheduling System

3.1.4. SYSTEMS LEVEL MODEL

The System Level Model is constructed from the systems within the categories which constitute the domain of the Logical Ground Terminal. First, the above defined systems are linked together to constitute the Systems Categories Model, as shown in Figure 3-5. As with all the models in this document which show control and data flow, this is an example only. It uses one and only one instance of each identified item. A real implementation would almost always have more than one instance of some items, and few implementations would have all the items shown.

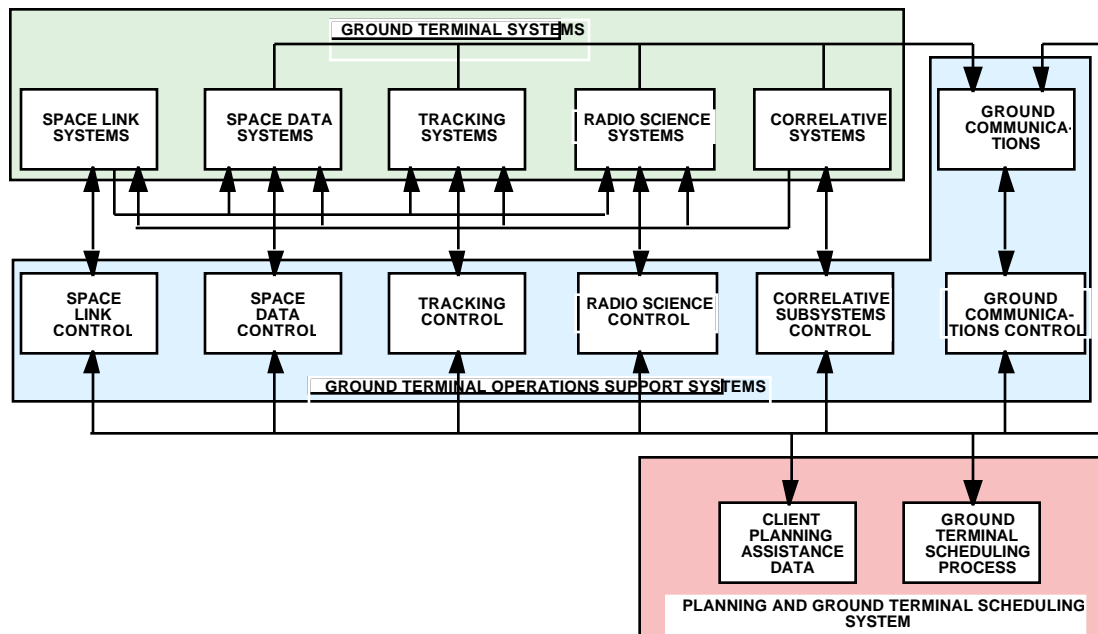


Figure 3-5 - Systems Categories Reference Model

3.2. IDENTIFICATION OF OBJECTS WITHIN SYSTEMS

3.2.1. SPACE LINK SYSTEMS

Within the Space Link category are three systems. These are antenna, receiving, and transmitting (Figure 3-6). They are all “Mainstream” items which move data to/from the spacecraft.

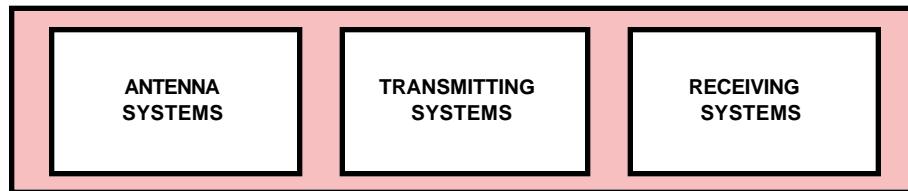


Figure 3-6 - Systems Within the Space Link Systems Category

3.2.1.1. Antenna

There are three objects within the antenna system (**Figure 3-7**). Only one of these, the steerable antenna, has a control object.

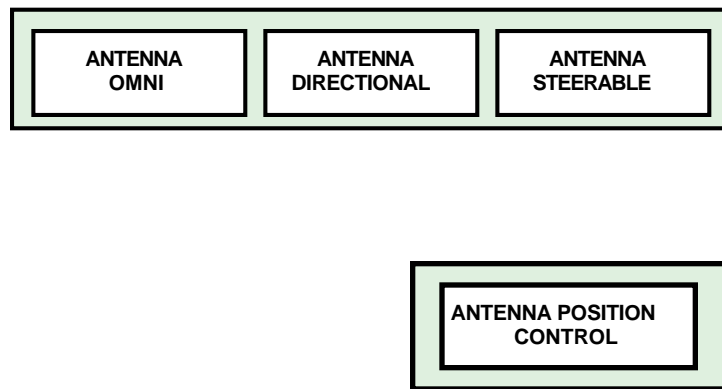


Figure 3-7 - Antenna System Objects

Super MOCA Ground Terminal Reference Model

An example of a possible implementation using the identified objects is shown in **Figure 3-8**.

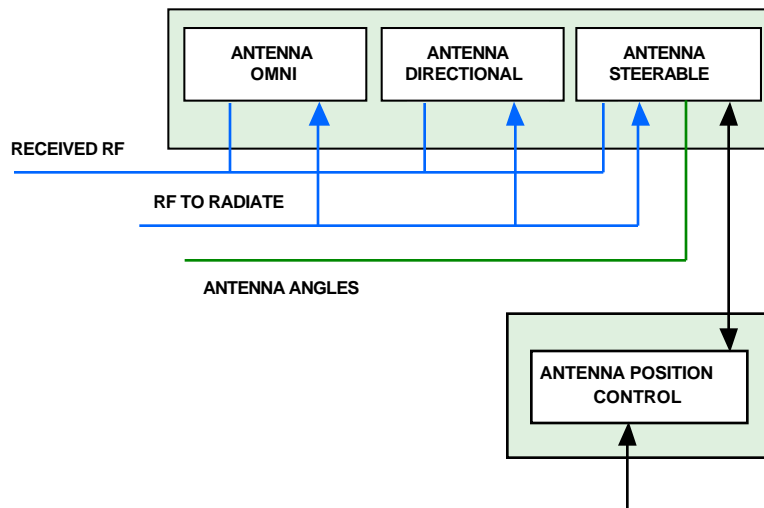


Figure 3-8 - Example Antenna System Implementation

3.2.1.2. Transmitting

Within the transmitting system are the transmitter, the exciter, the channelizer - e.g. subcarrier generator -, and the modulator (**Figure 3-9**). Each of these has a control object

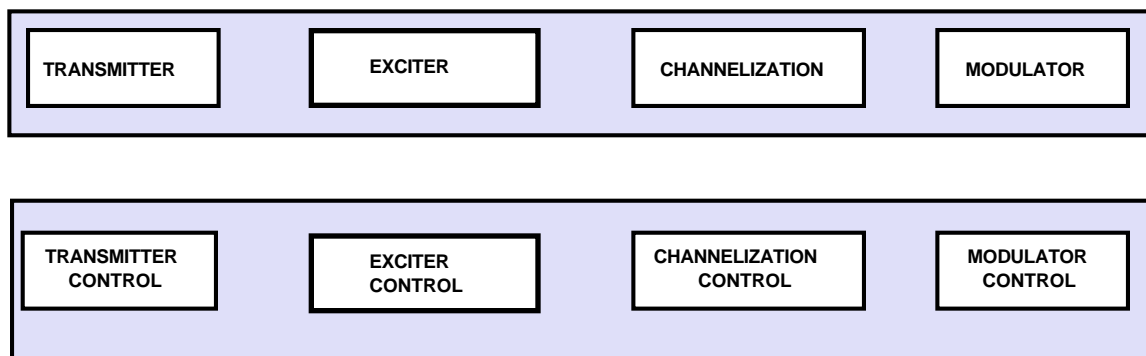


Figure 3-9 - Transmitting System Objects

An example of a possible implementation using the identified objects is shown in **Figure 3-10**.

Super MOCA Ground Terminal Reference Model

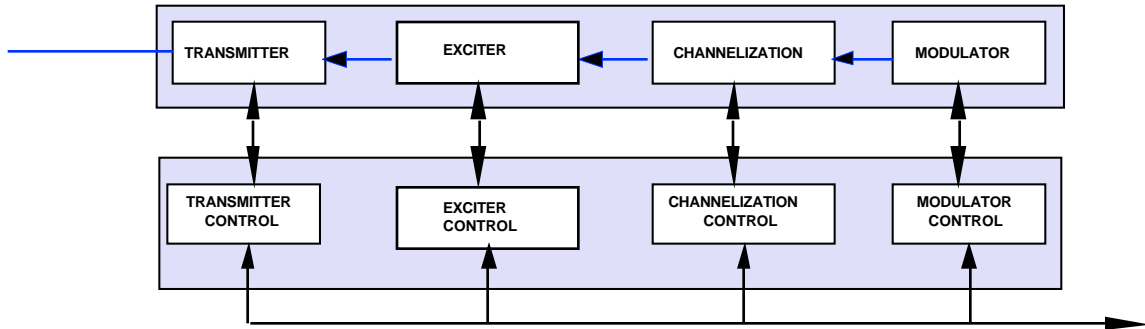


Figure 3-10 - Example Transmitting System Implementation

3.2.1.3.Receiving

Within the receiving system are the downconverter, the receiver, the dechannelizer - e.g. subcarrier discriminator -, and the demodulator (**Figure 3-11**). Each has a control object.

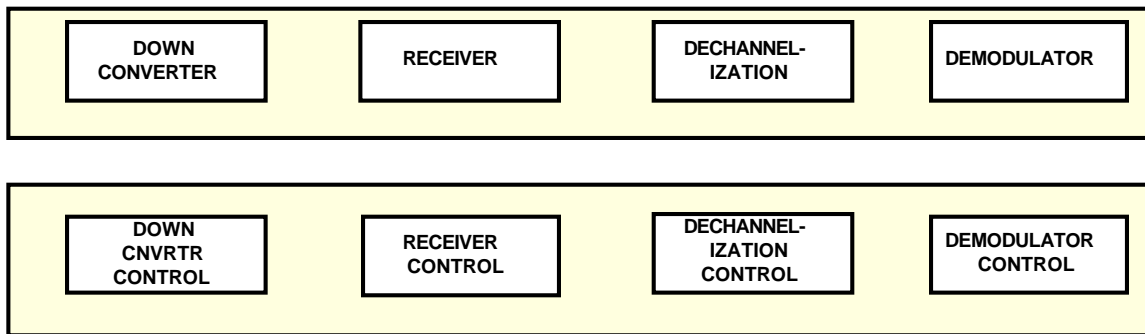


Figure 3-11 - Receiving System Objects

An example of a possible implementation using the identified objects is shown in **Figure 3-12**.

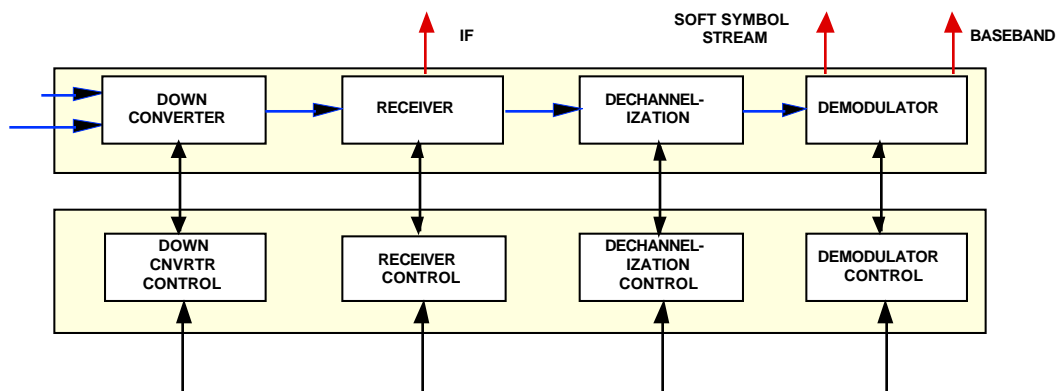


Figure 3-12 - Example Receiving System Implementation

3.2.2. SPACE DATA SYSTEMS

Within the Space Data systems category are two systems. These are the uplink system and the downlink system (Figure 3-13). These are “Mainstream” systems which move protocol data units to/from the spacecraft. (Both uplink and downlink communications functions for Mainstream are being defined by CCSDS Panel 3.) Each of the systems has a control object. Each Space Data System utilizes some of the systems in the Space Link Systems Category and in the Correlative Systems Category, as well as in the Ground Terminal Operations Support Systems Category.

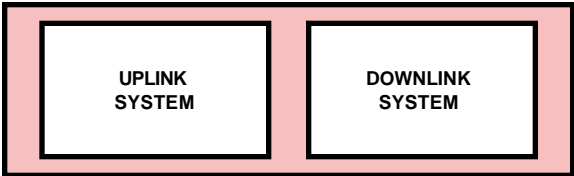


Figure 3-13 - Systems Within the Space Data Systems Category

3.2.2.1.Uplink System

The objects within the Uplink System are the Packet Multiplexer, the Virtual Channel Multiplexer, the Error Correction Code Generator, the Frame Generator, the Uplink Retranmission Process, the Retranmission Storage, the Station Stored Commands, and the real-time Commands. The Uplink System has one Control Object. See Figure 3-14.

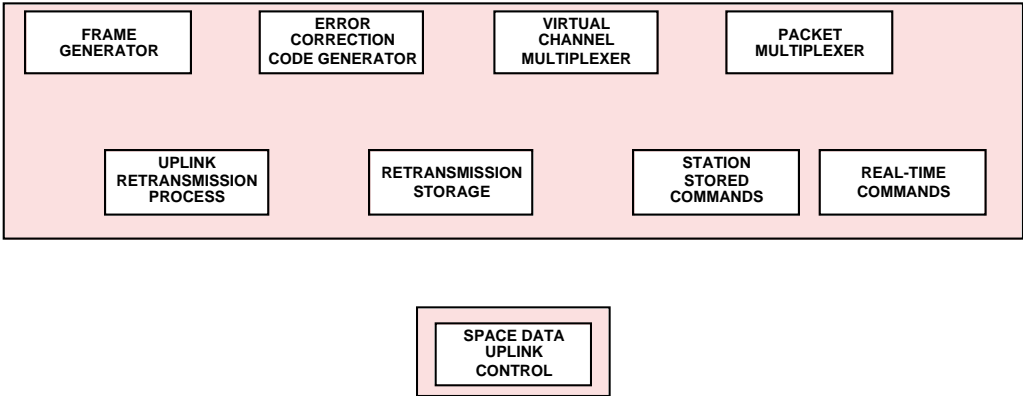


Figure 3-14 - Uplink System Objects

An example of a possible implementation using the identified objects is shown in **Figure 3-15**.

Super MOCA Ground Terminal Reference Model

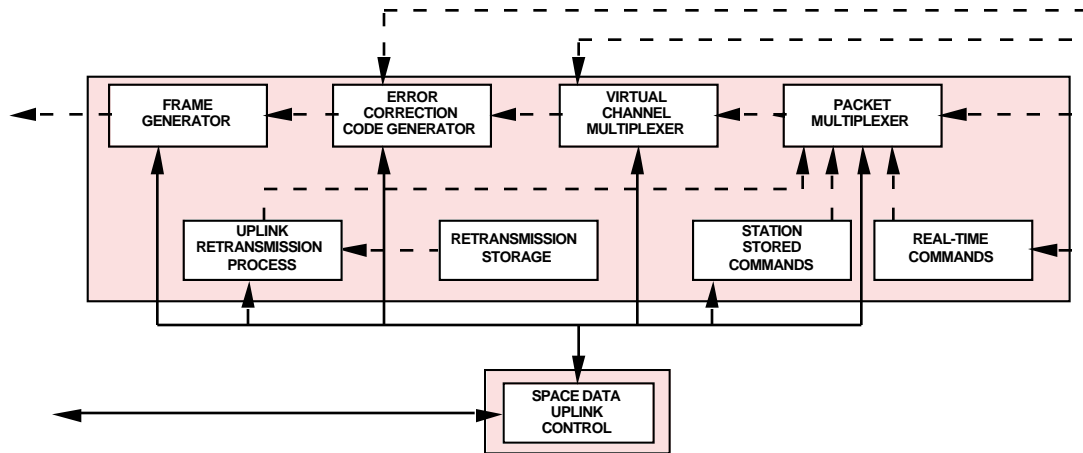


Figure 3-15 - Example Uplink System Implementation

3.2.2.2. Downlink System

The objects within the Downlink System are the Bit Synchronizer, the Convolutional Decoder, the Frame Synchronizer, the Error Correction Decoder, the Virtual Channel Demultiplexer, the Packet Demultiplexer, the Packet Selection process, the Downlink Retransmission Process, and the Virtual Channel Selection. The Downlink System has a single Control Object (**Figure 3-16**).

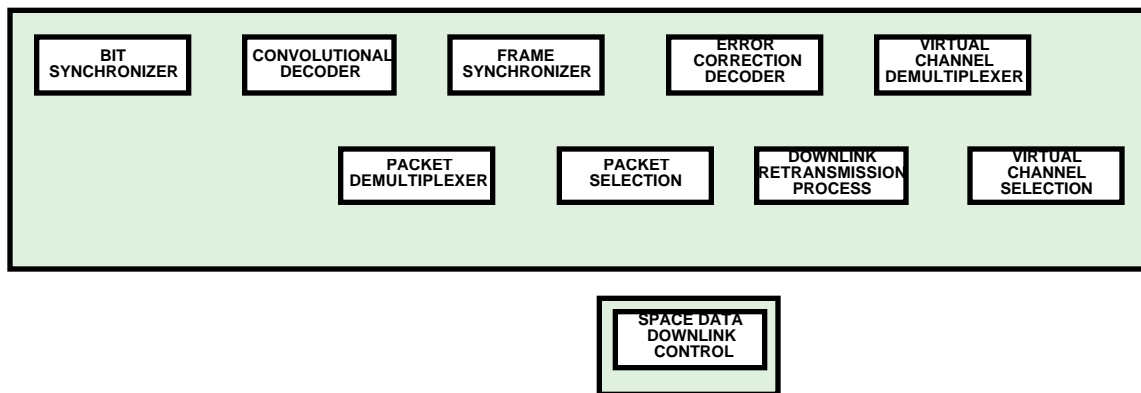


Figure 3-16 - Downlink System Objects

An example of a possible implementation using the identified objects is shown in **Figure 3-17**.

Super MOCA Ground Terminal Reference Model

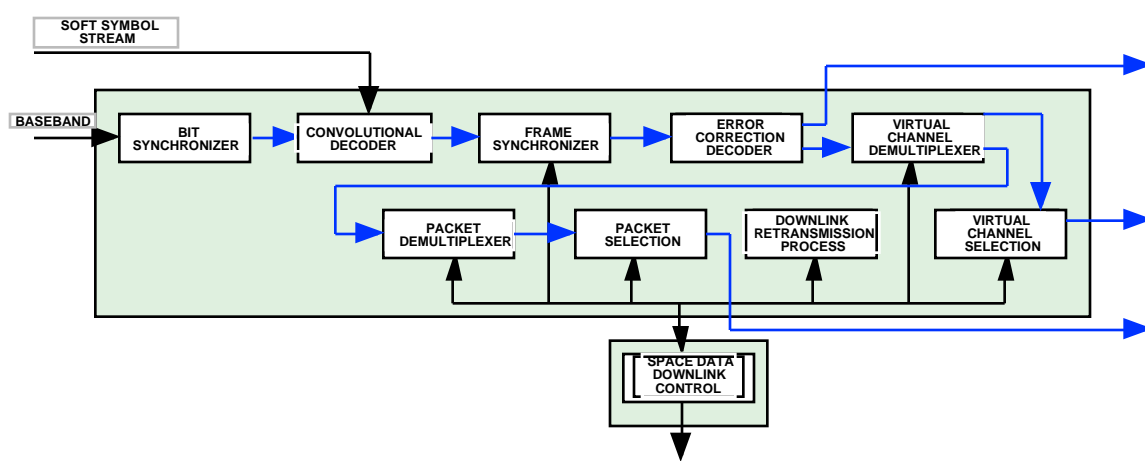


Figure 3-17 - Example Downlink System Implementation

3.2.3. TRACKING SYSTEMS

Within the Tracking Systems Category are five systems; Antenna Angles, Tone Ranging, Doppler, Radar, and Interferometric, as shown in **Figure 3-18**. The objects within each system are defined in the following subsections. Each system has a control object. Each Tracking System utilizes all or some of the systems in the Space Link Systems Category and in the Correlative Systems Category, as well as in the Ground Terminal Operations Support Systems Category. In addition, the Tracking Systems within the Ground Terminal are data gathering systems. The processing of the gathered data and the determination of the tracking values are accomplished off-site, and are therefore not included in the Ground Terminal Reference Model.

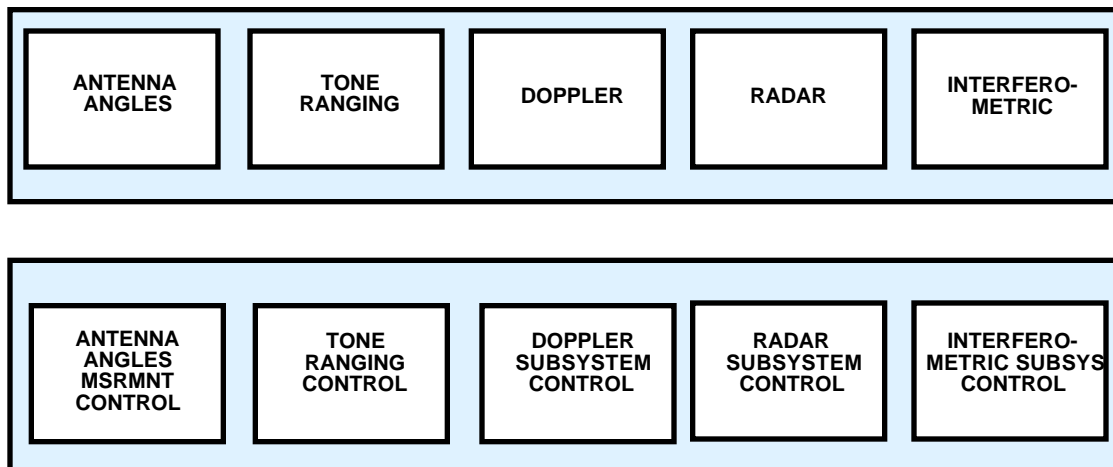


Figure 3-18 - Systems within the Tracking Systems Category

3.2.3.1. Antenna Angles Measurement

The Antenna Angles Measurement System contains a single process Object, the Antenna Data Converter, and a single control Object (Figure 3-19 - Antenna Angles Measurement System Objects).

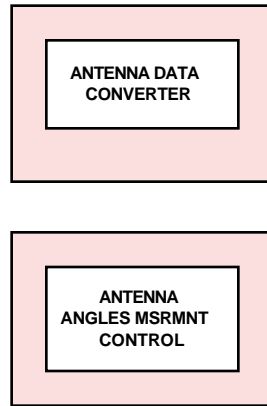


Figure 3-19 - Antenna Angles Measurement System Objects

An example of a possible implementation using the identified objects is shown in **Figure 3-20**.

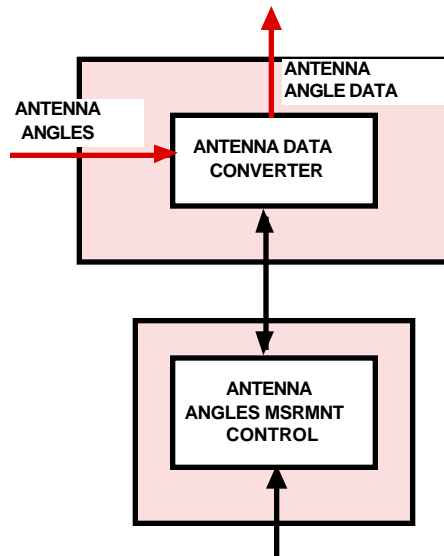


Figure 3-20 - Example Antenna Angles Measurement System Implementation

3.2.3.2. Tone Ranging

The Tone Ranging System contains four objects, the Measurement Processor, the Signal Processor, the Sequence Controller, and the Tone Generator. The Tone Ranging System has a single control Object (Figure 3-21).

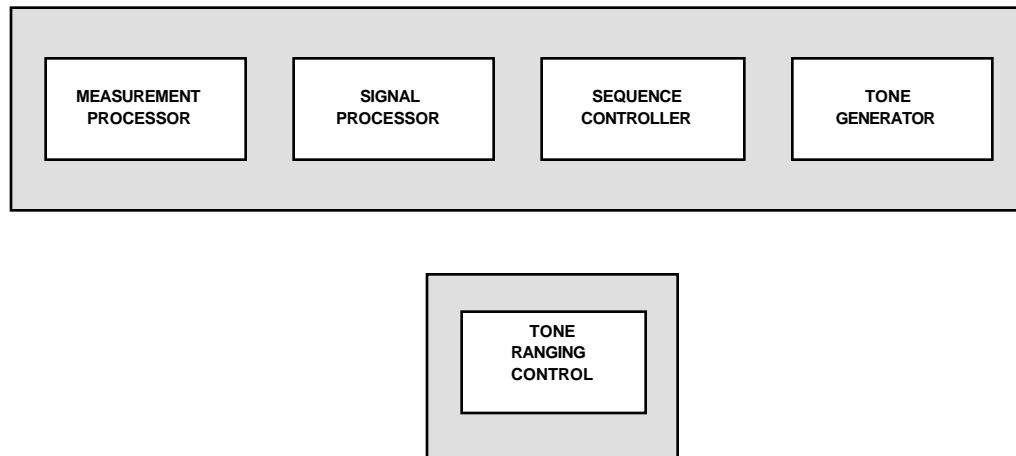


Figure 3-21 - Tone Ranging System Objects

An example of a possible implementation using the identified objects is shown in **Figure 3-22**.

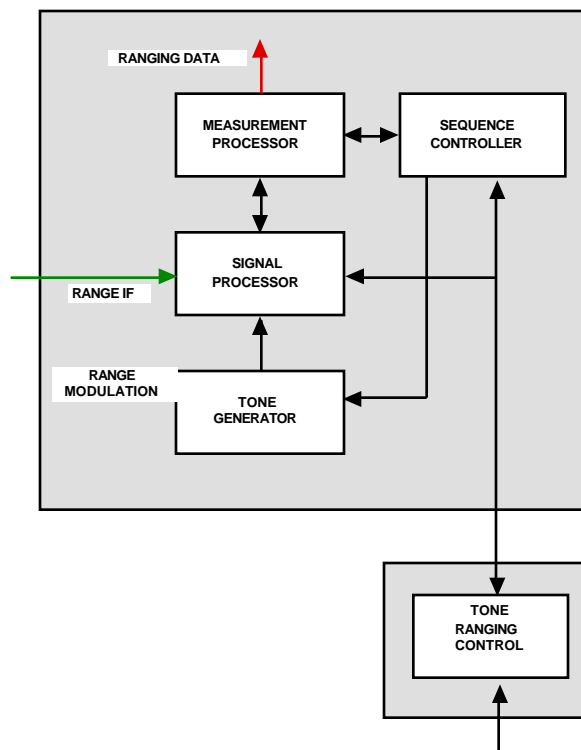


Figure 3-22 - Example Tone Ranging System Implementation

3.2.3.3.Doppler

The Doppler System contains three objects, the Measurement Processor, the Signal Processor, and the Doppler Extractor. It has a single control object. See Figure 3-23.

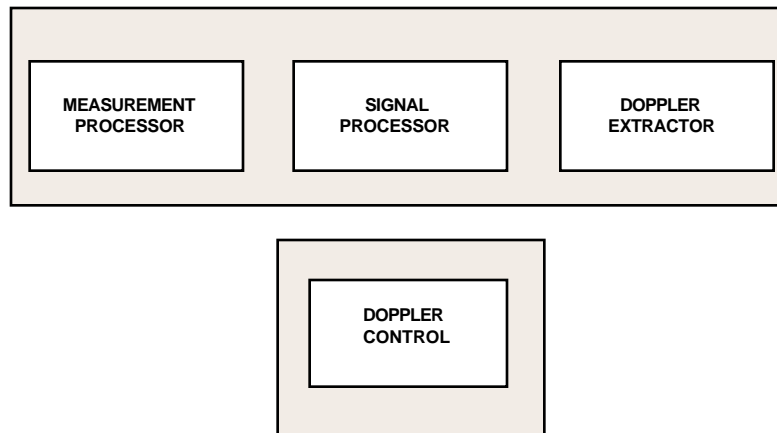


Figure 3-23 - Doppler System Objects

An example of a possible implementation using the identified objects is shown in **Figure 3-24**.

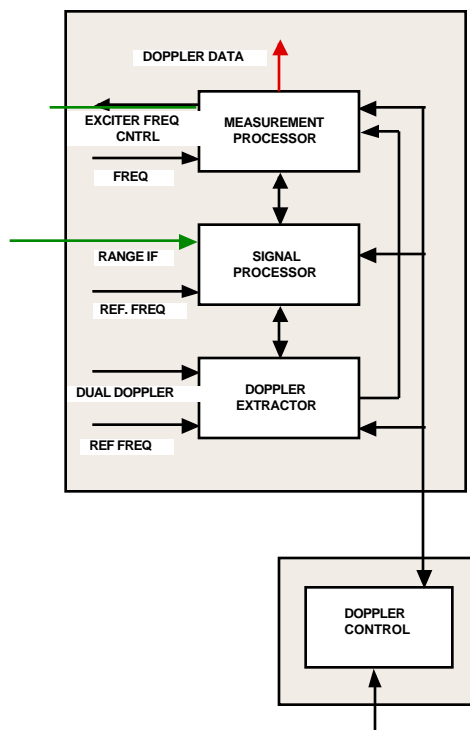


Figure 3-24 - Example Doppler System Implementation

3.2.3.4. Radar

The Radar System contains the Formatter, PLO, Modulator, Processor, and (internal) Control objects. It has a single control object. See Figure 3-25.

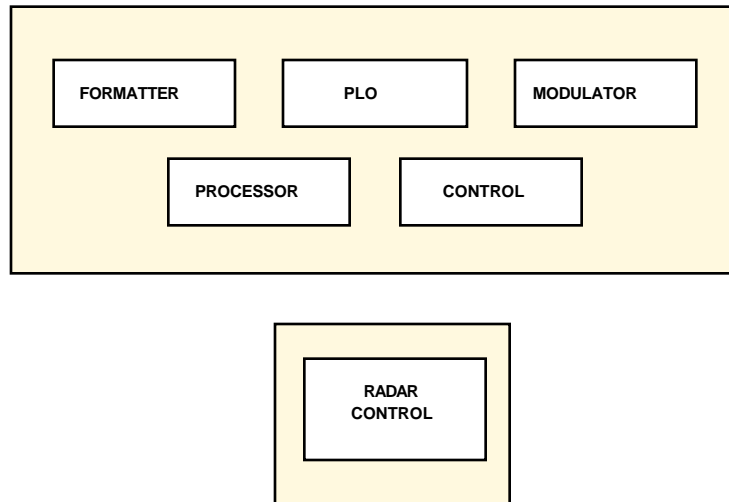


Figure 3-25 - Radar System Objects

An example of a possible implementation using the identified objects is shown in **Figure 3-26**.

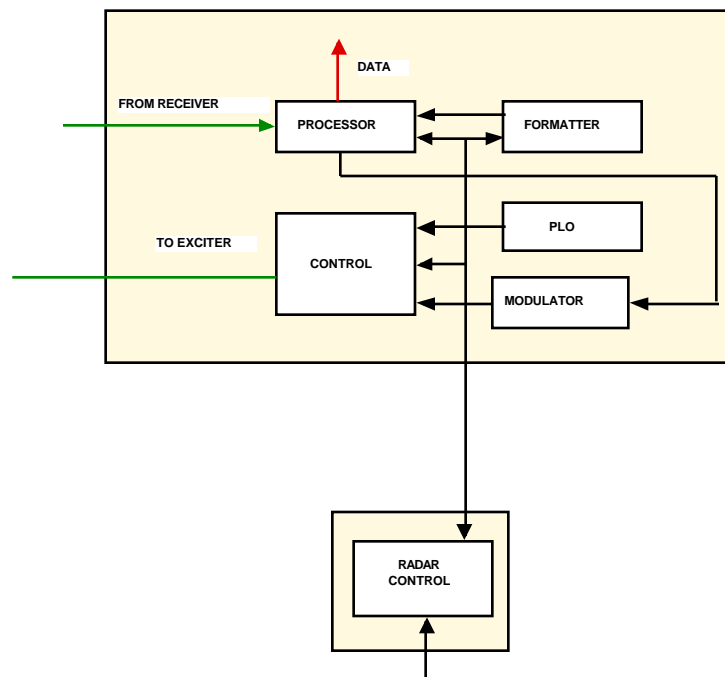


Figure 3-26 - Example Radar System Implementation

3.2.3.5. Interferometer

The Interferometer System contains IF to Video Down Converter, Signal Digitizer, (internal) Controller, and Data Formatter objects. The system has a single control object. See Figure 3-27.

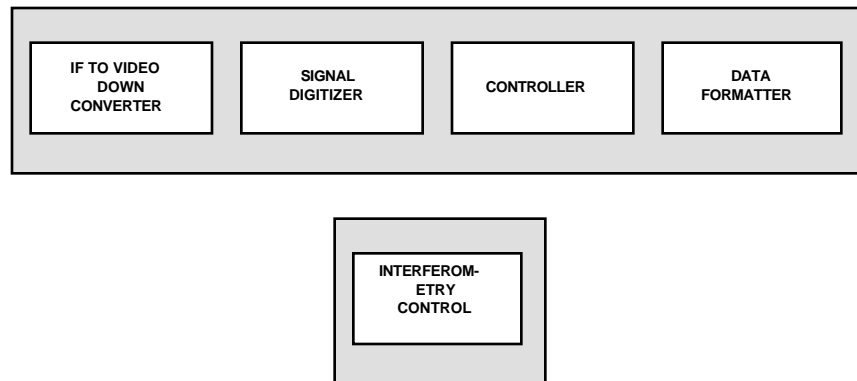


Figure 3-27 - Interferometer System Objects

An example of a possible implementation using the identified objects is shown in **Figure 3-28**.

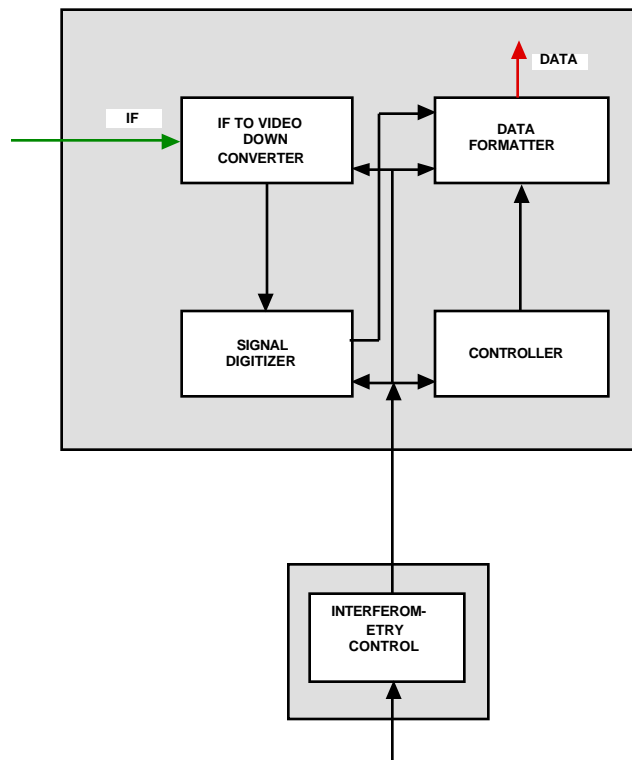


Figure 3-28 - Example Interferometer System Implementation

Super MOCA Ground Terminal Reference Model

3.2.4. RADIO SCIENCE SYSTEM

The Radio Science System contains nine objects. They are IF to Video Down Converter, Signal Digitizer, Signal Strength Measuring, Frequency Measuring, Spectrum Analyzer, Stability Analyzer, Data Formatter, Frequency Synthesizer/Controller, Radiometric Control, and Data Formatter (**Figure 3-29**). The Radio Science System has one Control object. The Radio Science System utilizes all or some of the systems in the Space Link Systems Category and in the Correlative Systems Category, as well as in the Ground Terminal Operations Support Systems Category. In addition, the Radio Science System is a data gathering system. The processing of the gathered data is accomplished off-site, and is therefore not included in the Ground Terminal Reference Model.

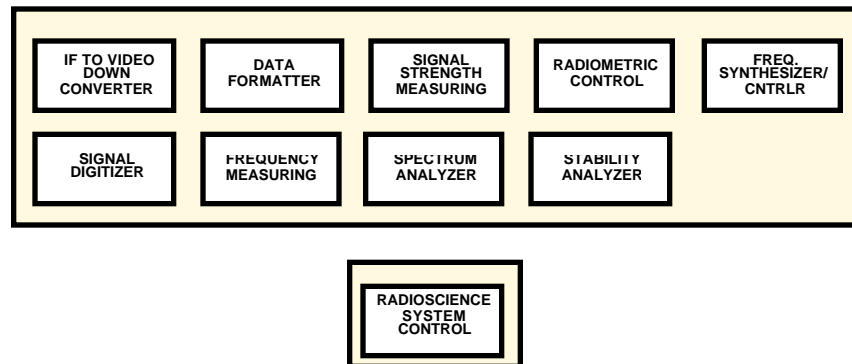


Figure 3-29 - Radio Science System Objects

An example of a possible implementation using the identified objects is shown in **Figure 3-30**.

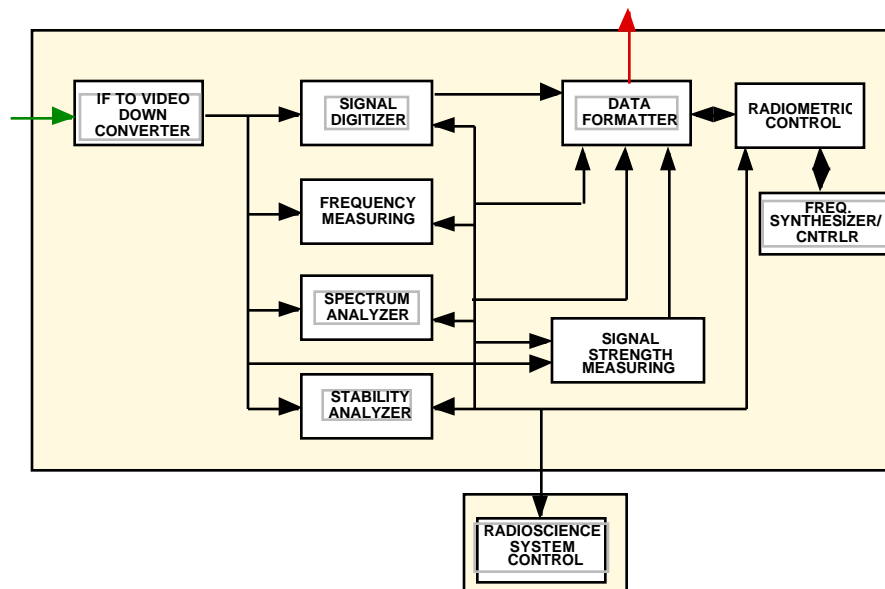


Figure 3-30 - Example Radio Science System Implementation

Super MOCA Ground Terminal Reference Model

3.2.5. CORRELATIVE SYSTEM

Two systems have been identified within the Correlative Data system. They are Time and Weather, as shown in **Figure 3-31**. The Time System includes the generation of Reference Frequencies as well as of Time Signals. All other systems use one or more of these signals.

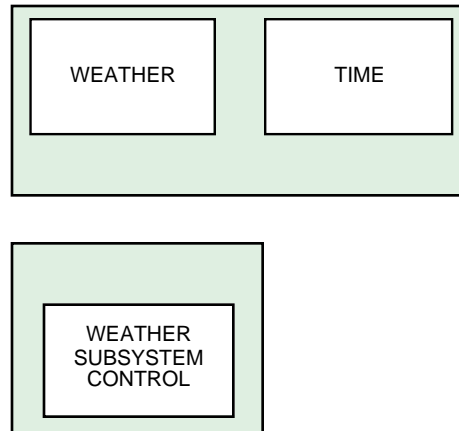


Figure 3-31 - Correlative Systems Objects

3.2.6. PLANNING AND SCHEDULING SYSTEM

Planning actually takes place within the Operations Center, not the Ground Terminal. However, the (logical) Ground Terminal maintains capabilities and status information accessible by the client for use in the planning activities. See **Figure 3-32**. Scheduling does take place within the (logical) Ground Terminal.

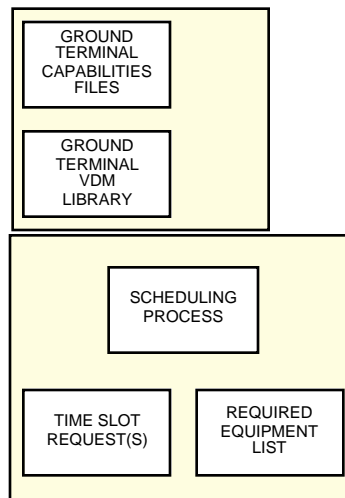


Figure 3-32 - Planning and Scheduling System Objects

Super MOCA Ground Terminal Reference Model

3.2.7. GROUND COMMUNICATIONS SYSTEM

The ISO Seven Layer Model is used as the Ground Communications Model. A separate protocol stack is shown in **Figure 3-33** for each of the primary communications traffic types to facilitate identifying desirable protocol features for each of those types.

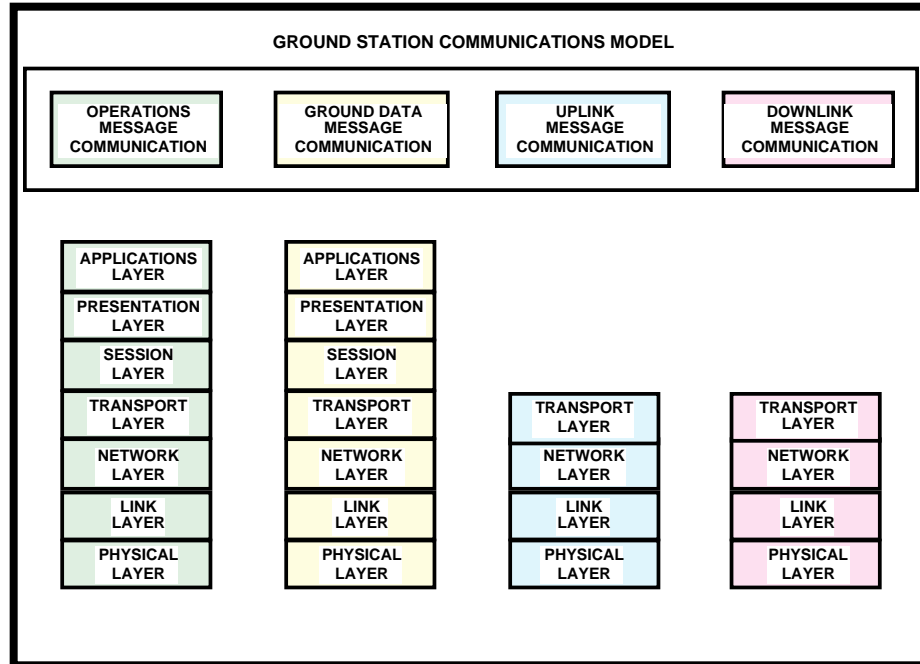


Figure 3-33 - Ground Terminal Communications Model

3.2.8. DATA OBJECTS

The Data objects shown in **Figure 3-34** are known to be required in the Model.

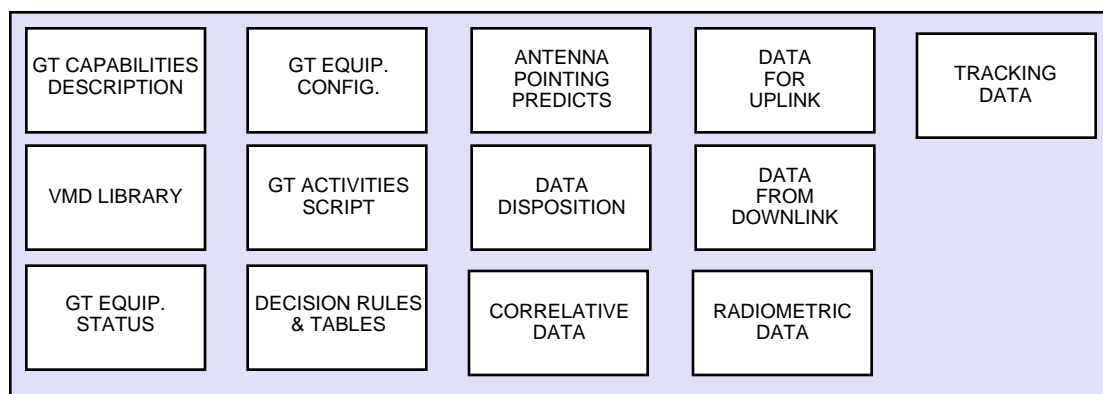


Figure 3-34 - Data Objects

3.3. CONTROL AND DATA FLOW MODELS

3.3.1. SYSTEM LEVEL CONTROL AND DATA FLOW MODEL

Having defined the component systems, and the objects contained in them, example architectures have been generated. As with all the models in this document which show control and data flow, this is an example only. They use one and only one instance of each identified item. A real implementation would almost always have more than one instance of some items, and few implementations would have all the items shown. The figures simply represent possible architectures, and their usefulness is in helping to evaluate the completeness of the object identification process, *not* in designing real ground terminals.

Having generated example architectures based on the objects identified, these example architectures have then been used to generate an overall example of a station architecture, or Control and Data Flow Model, as shown in Figure 3-35.

The flow of "Mainstream" data, that is, data bound for and received from the spacecraft, has been separately marked.

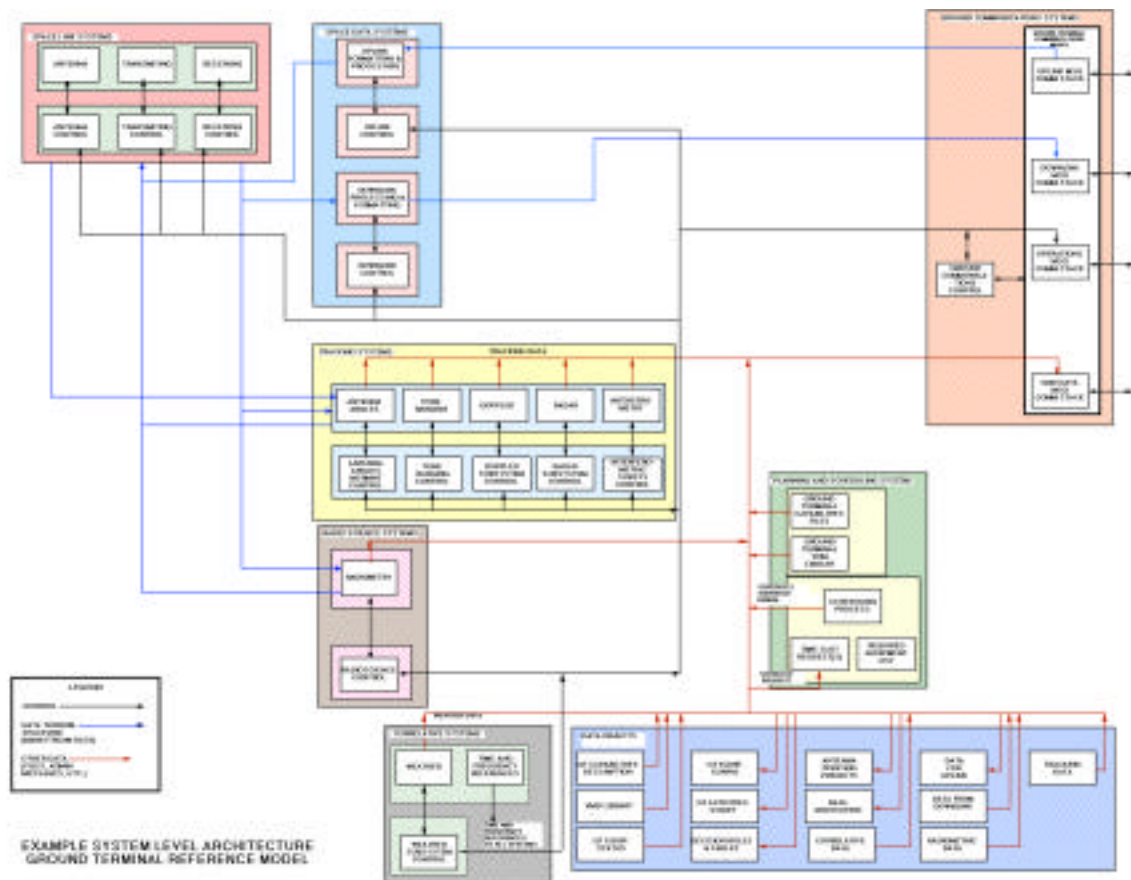


Figure 3-35 - Example System Level Ground Terminal Architecture

Super MOCA Ground Terminal Reference Model

An example of an object level model of a Ground Terminal is shown in .Figure 3-36. As with all the models in this document which show control and data flow, this is an example only. It uses only one instance of each identified object (a real implementation would almost always have more than one instance of several objects), and uses all identified objects (few implementations would have all the objects shown).

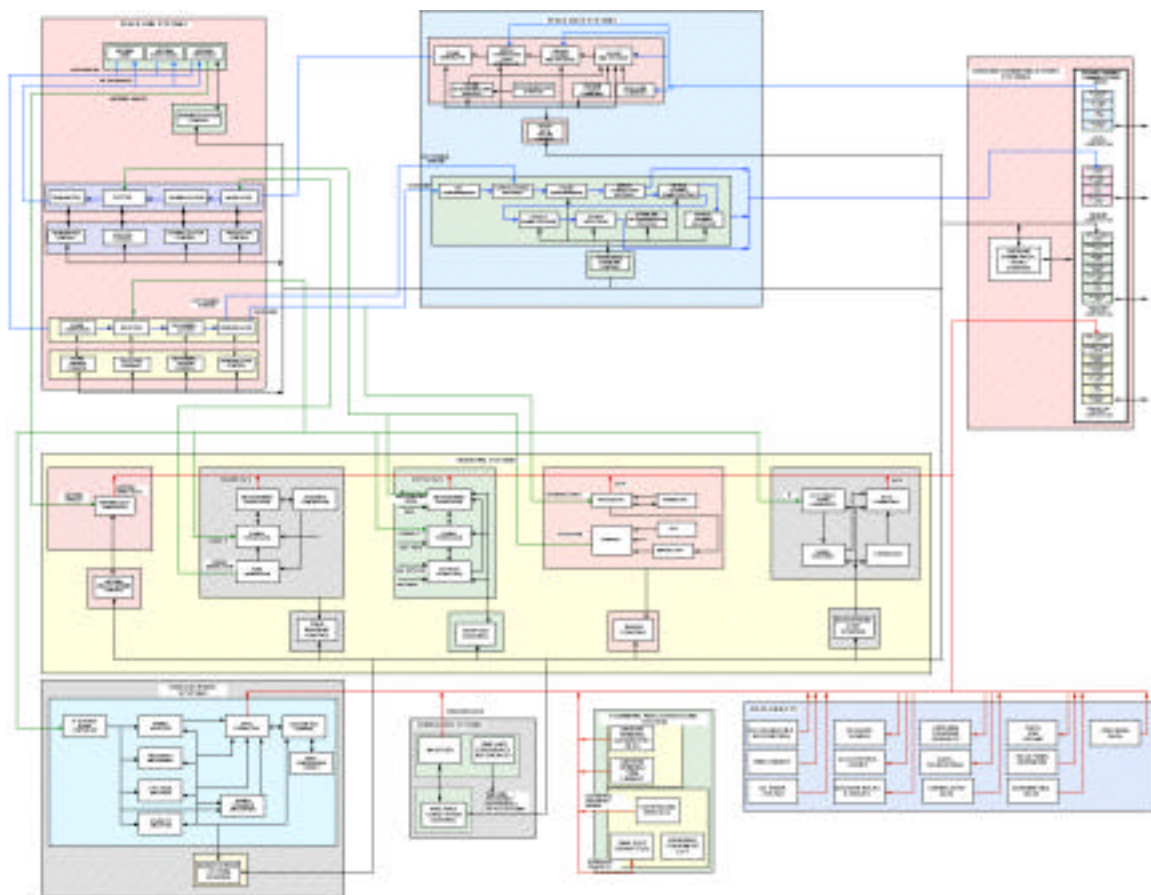


Figure 3-36 - Example Object Level Ground Terminal Architecture

4. ISSUES LIST

4.1. DECISION SUPPORT LOGIC

Decision Support Logic can be incorporated at any of the levels, from specific devices through VFDs and systems to the Ground Terminal domain as a whole. It is not clear to the author how to show this within the Reference Model, except possibly at the highest level, that is, as an operator assistance tool.

4.2. OPERATIONS MANAGEMENT

Overall operations management processes are not obvious in the current model. That is to be expected of a reference model, but a method to establish a baseline for evaluation of operations management protocols is not intuitively clear to the author.

4.3. COMMUNICATIONS STACKS

Separate ground communications stacks are shown for operations messaging, ground data and administrative messaging, uplink messaging, and downlink messaging. This is to facilitate evaluating the protocol needs of these uses. In actual implementation it is certain that some of these stacks will be merged to a greater or lesser degree. Two examples of possible merged stacks are shown below. First (Figure 4-1) is one in which a single network is used for all ground communications (a la the Internet). The second example (Figure 4-2) demonstrates a possible configuration using an "open" network for operations messaging and ground data and administrative messaging, and a different, perhaps secure, network for uplink messaging and downlink messaging.

Super MOCA Ground Terminal Reference Model

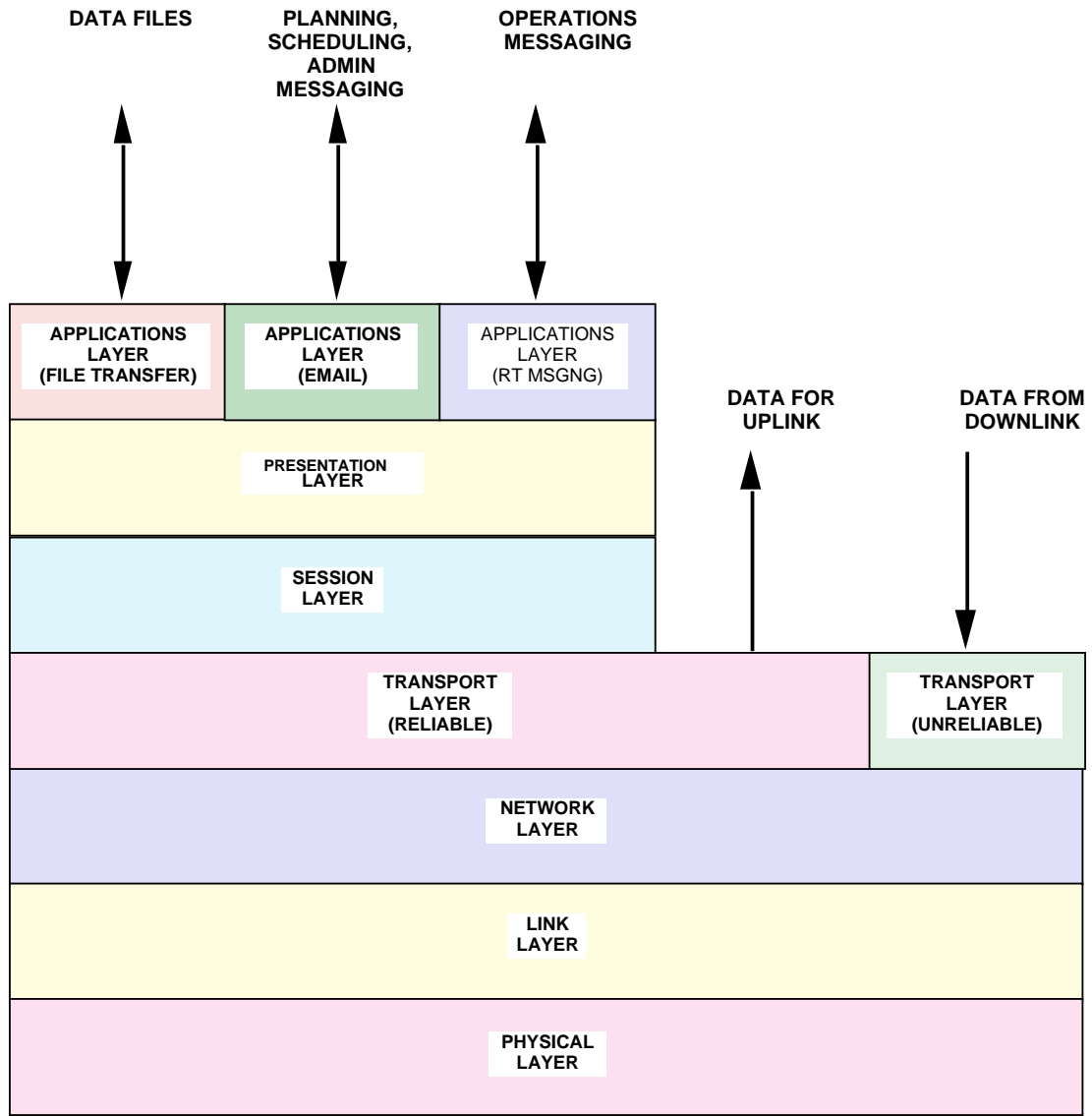


Figure 4-1 - Single Network Example

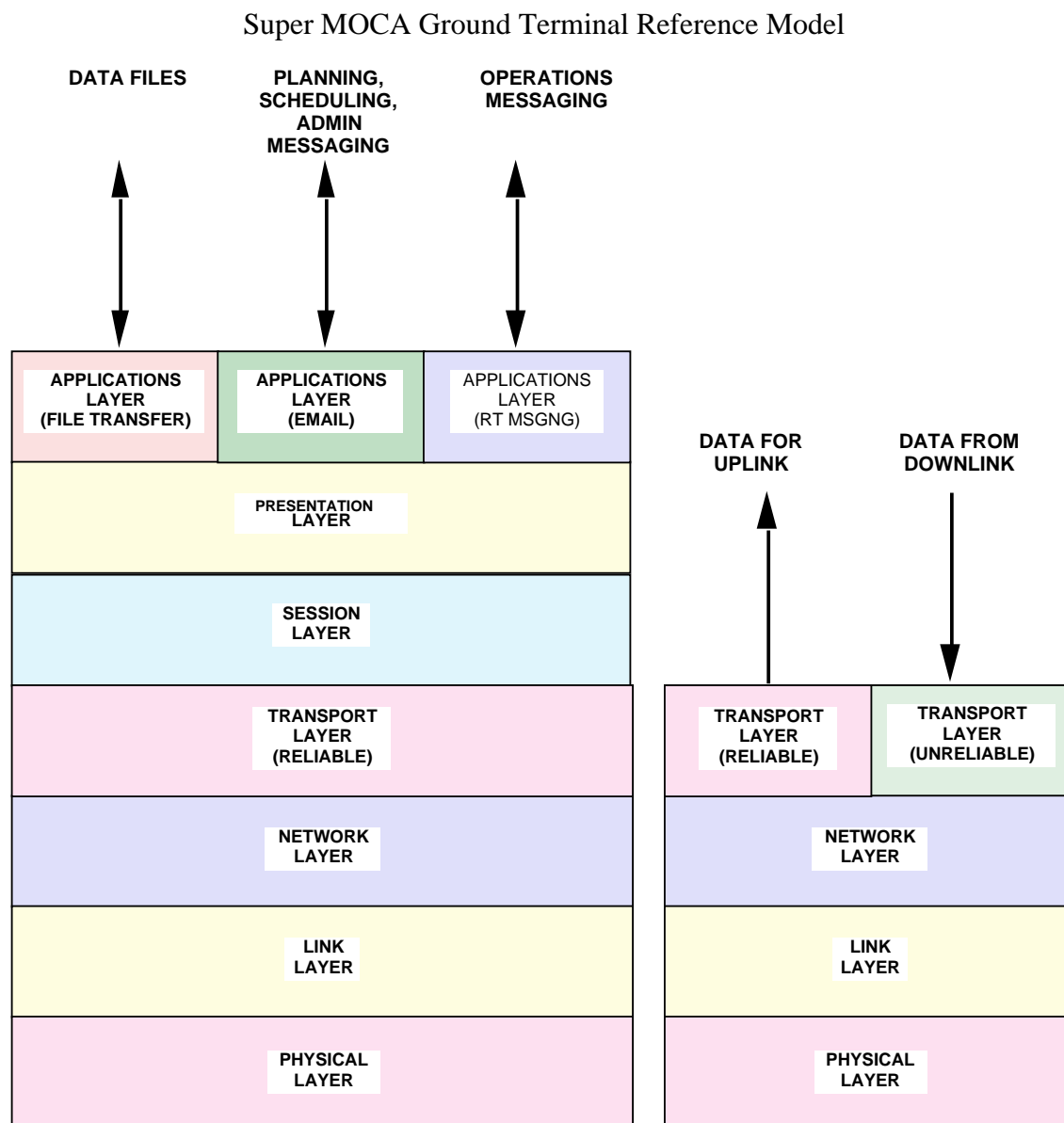


Figure 4-2 - Dual Network Example

4.4. PROTOCOL INTERFACES

The interfaces for the application level protocols are shown as part of the protocol analysis work.

4.5. SCPS PROTOCOLS

The SCPS protocols do not appear in these models. That is because they are basically Operations Center to Spacecraft protocols. When the protocols are terminated in the Ground Terminal the Ground Terminal is acting as an agent for the Operations Center. It is not clear that this should be added to the Reference Model.